

Assessment of Functional Hearing Abilities for Hearing-Critical Jobs: The Canadian Experience

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Overview

- ❑ Introductions
- ❑ Background to the problem
- ❑ Key concepts:
 - Functional hearing assessment
 - Hearing-critical tasks
- ❑ Project rationale and implementation
- ❑ Functional screening criteria
- ❑ Implementation of the functional screening program
- ❑ Summary and discussion

Introductions and Acknowledgments

- ❑ Sigfrid Soli: House Ear Institute
- ❑ Stephen Peck: Canadian Coast Guard, Department of Fisheries and Oceans
- ❑ Malcolm Farquhar: Conservation and Protection, Department of Fisheries and Oceans
- ❑ Philip Prendergast, MD: Health Canada
- ❑ The research team: University of Ottawa and House Ear Institute

Stephen Peck
Canadian Coast Guard
Department of Fisheries and Oceans

Director, Marine Personnel
Fleet Directorate
Ottawa

Canadian Coast Guard

Department of Fisheries and Oceans

- ❑ Marine Delivery Arm of DFO, supporting Coast Guard, Fisheries Conservation and Protection, and Marine Science
- ❑ 2,200 Officers and Crew and 113 Vessels from Motor Life Boats to Icebreakers
- ❑ Five regional bases across Canada
- ❑ Operations in all three Oceans



Typical Fleet Operations



Seagoing Personnel

- ❑ Coast Guard is a merchant fleet subject to *Canada Shipping Act (2001)* regulated by Transport Canada
- ❑ As a government fleet we are public servants first and mariners second
- ❑ All mariners must have valid medical certification:
 - Transport Canada issues Seafarer's Medical for non-government merchant marine (including fishermen)
- ❑ Health Canada (HC) administers medical examinations for public servants
 - CCG seagoing personnel:
 - Every 3 years < 40
 - Every 2 years > 40
 - More stringent than Transport Canada Seafarer's Medical
 - Hearing is part of assessment
- ❑ HC certifies / denies individual as Fit for Duty

Why Medical Certification is Required

- ❑ Need for Coast Guard seagoing and C&P Fishery Officers to be medically fit
- ❑ Occupational Health and Safety issue for employee and liability concerns for Management (Due Diligence)
- ❑ Hearing is part of medical assessment:
 - Wide range of environmental noise and operational conditions;
 - Different auditory skills required (i.e. speech perception, signal detection, sound localization);
 - Minimum level of functional hearing abilities required by personnel to ensure safe operations

Background to the Problem

- ❑ In 1995 a recruit to the Coast Guard was refused employment on the basis of asymmetrical hearing loss
- ❑ Filed discrimination complaint through Canadian Human Rights Commission (CHRC)
- ❑ CHRC ordered DFO to review the current hearing standard
- ❑ **The Objective: Establish a hearing standard that:**
 - Does not unnecessarily exclude able candidates
 - Is the minimum to do the job safely and efficiently
 - Is evidence-based and defensible as a *Bona Fide* Operational Requirement (BFOR)
 - Is FAIR

Previous Hearing Standard

- ❑ **Adopted in 1980's (based on RCMP/DND/HC recommendations)**
- ❑ Pure Tone Audiogram:
 - No more than 25 dB loss in better ear and
 - No more than 30 dB loss in poor ear
 - Range from 500 to 3000 Hz
- ❑ Standards based on PTA are not sufficiently predictive of functional hearing abilities
- ❑ Developed a practical test, but
 - While reasonable in Management's opinion it was rejected by CHRC as not meeting criteria for a BFOR

Steps to Establish BFOR for Hearing

1. Identify hearing requirements and measure noise environments during Hearing Critical (HC) tasks
2. Identify screening measures of functional hearing abilities
3. Relate screening measures to performance in real noise environments for normal hearing individuals via laboratory studies
4. Validate the relationship of screening measures to functional hearing abilities in noise environments
5. Validate the model's predictions with Subject Matter Experts' (SME) communication requirements
6. Apply the model to establish functionally-based criteria for HC tasks;
7. Validate the functionally-based criteria with CCG/C&P incumbents; and
8. Implement new Hearing Standard and Screening Protocol as part of medical assessment

**Malcolm Farquhar:
Conservation and Protection,
Department of Fisheries and Oceans**

Department of Fisheries and Oceans Conservation & Protection Branch (C&P)

- ❑ Conservation Policing Service for the Department of Fisheries and Oceans
- ❑ 2nd largest federal policing agency
- ❑ Protect Canada's fishery resources
- ❑ 650 sworn and armed officers
- ❑ Officers deployed on commercial, recreational, and aboriginal fishing and habitat related activities



Conservation & Protection

From Sea to Sea



- ❑ Highly decentralized
- ❑ 170 detachments

Conservation & Protection Work Environment



Role of Subject Matter Experts

- **Subject Matter Experts (SME's)** = Fishery Officers/CCG Officers/Crew with significant and recent field experience

Two Roles

- 1999 - Task Analysis
- 2003 - Identifying Communication Requirements for Hearing Critical Tasks

Role of Subject Matter Experts

❑ Detailed Task Analysis - BCRI 1999

❑ Four Stages –

- job descriptions and previous material
- questionnaires and surveys to SME's
- focus groups conducted with SME's
- site visits

❑ Resulted in 186 tasks carried out in 6 environments:

- Deck
- Engine
- Logistics
- Inshore Fishery Officers
- Offshore Fishery Officers
- Land Based Fishery Officers

Role of Subject Matter Experts

2003 Hearing Project

- ❑ SME's to identify communication requirements of hearing critical tasks (59)
- ❑ SME focus groups held across the country
 - Briefing on project/role
 - Confirmation of hearing critical tasks/location
 - Research documents, forms, rating guide

Role of Subject Matter Experts

We are assessing our ability to
hear sound, voice, alarms, etc

NOT

Someone else's ability to
understand our spoken
command

Role of Subject Matter Experts

TASK RATING

- ❑ 1. Auditory performance required to be heard
(speech, warning, localization)
- ❑ 2. In which of eight locations/environments is the task performed (office, vehicle, deck, etc)
- ❑ 3. Distance of communication – 3m, 3-6m, >6m
- ❑ 4. Can the message be repeated? Y/N
- ❑ 5. Voice level – whisper, normal, loud, shouted
- ❑ 6. Minimum level of hearing performance for safety - % of 100.

Role of Subject Matter Experts

CRITERIA FOR CONSOLIDATING REGIONAL TASK RATINGS

- ❑ Difference of opinion on whether a task is hearing critical - classify as hearing critical**
- ❑ Multiple distances identified - take the greatest**
- ❑ Discord on whether repeats are allowed - classify as no repeats**
- ❑ Discord on voice level - classify for minimum**
- ❑ Discord on performance level - take the highest**

SAFETY!

Role of Subject Matter Experts

PROBLEMS

impossible for a “normal” hearing person to achieve the required minimum level of performance

- ❑ Revisited problem tasks with SME group
- ❑ Findings:
 - sound recordings did not accurately reflect activity being undertaken
 - communications requirements too high

Role of Subject Matter Experts

-Results-

DFO HEARING CRITICAL TASKS

❑ *Shared between C&P / CCG*

i.e. - navigate vessel, react to alarms, don lifesaving equipment, etc



Fishery Officer (Offshore, inshore, land based)

- | | | |
|------|---------------------------|----------------------|
| i.e. | - inspection | - operate vessel/ATV |
| | - embark/disembark vessel | - foot patrol |
| | - make arrest | - vehicle stop |
| | - armed boarding | - surveillance |
| | - monitor alarms | - tow vessel |



Coast Guard MED (Marine Emergency Duties)

- | | | |
|------|------------------------|----------------------------|
| i.e. | - launch lifeboat/raft | - don lifesaving equipment |
| | - man overboard | - access/depart helicopter |

Philip Prendergast, MD:
Health Canada

Health Canada

□ Dr. Philip Prendergast

- Occupational Health Medical Officer
- Workplace Health & Public Safety Programme
 - Provider of occupational health services
 - More than 125 federal departments and agencies
 - Over 250,000 federal government employees across Canada
 - Primary consultant for DFO - C&P/CCG with respect to occupational fitness issues



Health Canada

Workplace Health & Public Safety Programme Offices



Research Team (2001-2004)

University of Ottawa	House Ear Institute (LA)
Chantal Laroche, PhD: PI Christian Giguère, Ph D Véronique Vaillancourt Josée Lagacé Martin Fortin Hugo Lafontaine Marie-Pierre Jolicœur	Sigfrid D. Soli, PhD Dan Freed Andy Vermiglio

Functional Hearing Assessment

Functional Hearing Ability

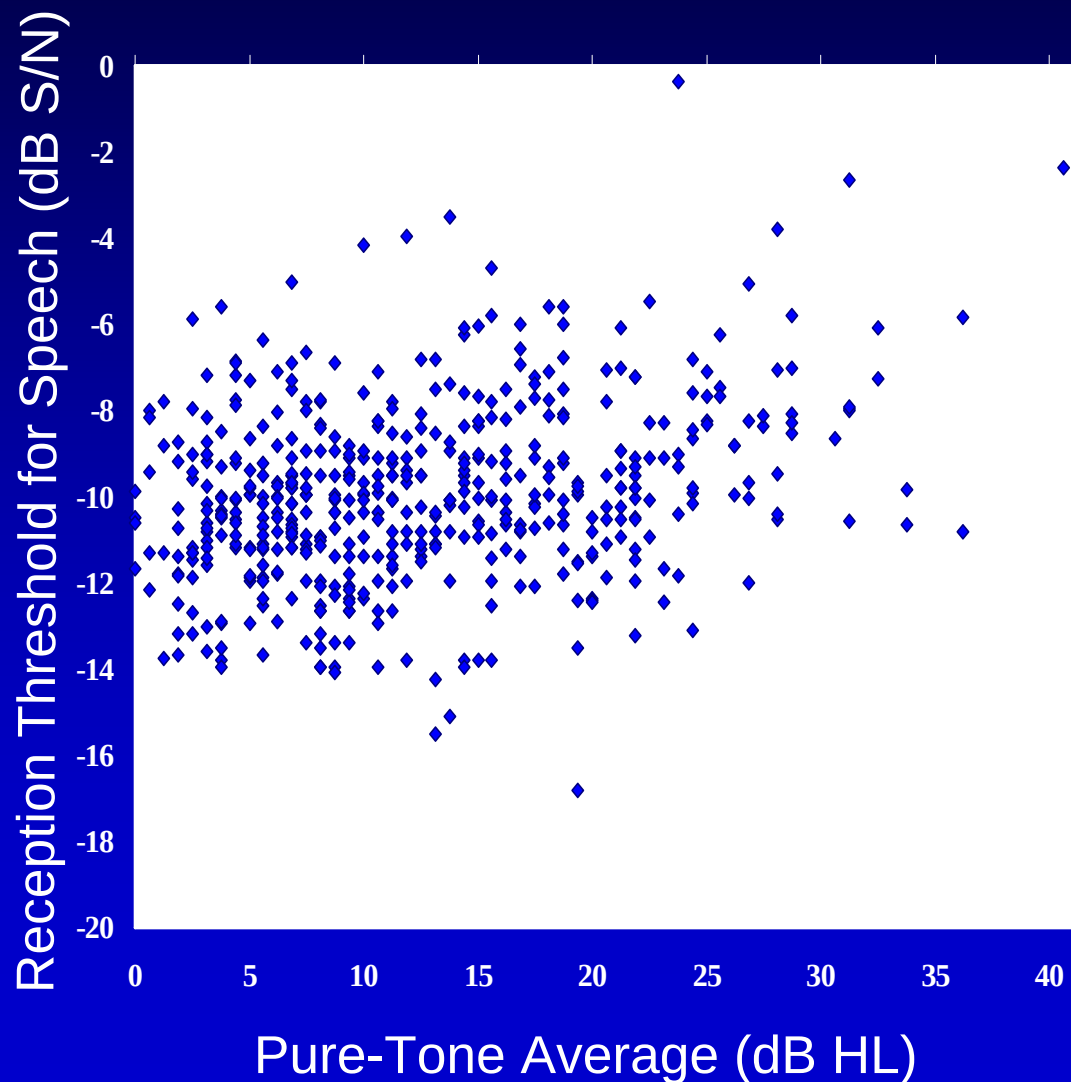
Functional hearing ability refers to the set of hearing abilities that enable a person to perform normally their daily activities that require hearing – especially those activities for which hearing is critical.

Aspects of Functional Hearing Assessment

- ❑ Functional hearing poorly predicted from basic diagnostic measures of hearing
- ❑ Audibility vs. distortion components of sensorineural hearing loss (Plomp's SRT model)
- ❑ Involves the binaural auditory system
 - Directional speech perception
 - Directional signal detection
 - Sound localization

Functional vs Diagnostic Measures

- ❑ Less than 25% of functional hearing ability is predictable from audiogram for moderate hearing losses



The Hearing In Noise Test: HINT

- ❑ Assessment of speech intelligibility by means of SRT measurements using an adaptive method
- ❑ Based on Plomp's SRT model
- ❑ Binaural measures in quiet and noise
- ❑ Adaptive - useable over a wide range of ability
- ❑ Sound field or headphone administration
- ❑ Norm-referenced, high reliability
- ❑ Computerized administration, scoring, and report generation

Assessment Protocol

SRT measurements

Condition	Speech Source	Noise Source	Noise Level
Quiet	Front (0°)	—	—
Noise Front	Front	Front	65 dB(A)
Noise Right	Front	Right (+90°)	65 dB(A)
Noise Left	Front	Left (-90°)	65 dB(A)

$$\text{Noise composite score} = (2\text{NF} + \text{NR} + \text{NL})/4$$

Norms & Measurement Error

English and French Norms

Language	Quiet [dB(A)]	Noise Front [dB S/N]	Noise Side [dB S/N]	Composite [dB S/N]
English	15.6	-2.6	-10.1	-6.35
French	16.4	-3.0	-11.4	-7.2

Test-retest confidence interval (95th) for HINT (dB)

Language	Quiet	All Noises	Composite Score
English	1.9	1.5	0.9
French	*2.0	2.2	1.2

*applicable after one practice list

Hearing Critical Tasks

Factors affecting job performance:

Nature of the job

- Hearing-critical task refers to a job function:
 - for which the sense of hearing is essential to perform the task
 - cannot be accommodated or compensated for by other senses
- Failure to perform essential functions endanger safety and effectiveness

Factors affecting job performance:

Workplace noise environment

- ❑ A hearing loss may affect performance in some environments, but not in others
- ❑ Effects of noise on performance are defined in relation to job requirements
- ❑ Noise profiles

Factors affecting job performance:

Task demands and parameters

- ❑ Job performance is not determined by the audiogram or by functional measures alone

- ❑ What level of performance is required?
 - Percent accuracy
 - Communication distance
 - Voice level
 - Repetition

Project Rationale and Implementation

Objectives

1. Identify or develop hearing tests that will address speech in noise, signal alarm detection, and localization
2. Ensure that the tests are directly applicable to the seagoing environment and job functions of all ships' departments, as well as C&P environments and job functions;
3. Validate the selected tests for CCG seagoing personnel and C&P seagoing and land-based personnel
4. Establish minimal acceptable auditory norms using the selected tests

Development & Validation Process

Seagoing activities

- Identify hearing-critical tasks
- Specify task locations

Laboratory simulations

- Re-create sound environments
- Control signal and noise

Clinical screening tests

- Use controlled signals and noises
- Simplified testing

Record CCG/C&P
sound environments
for tasks

3 tasks:

- Speech intelligibility
- Detection
- Localization

1 mode

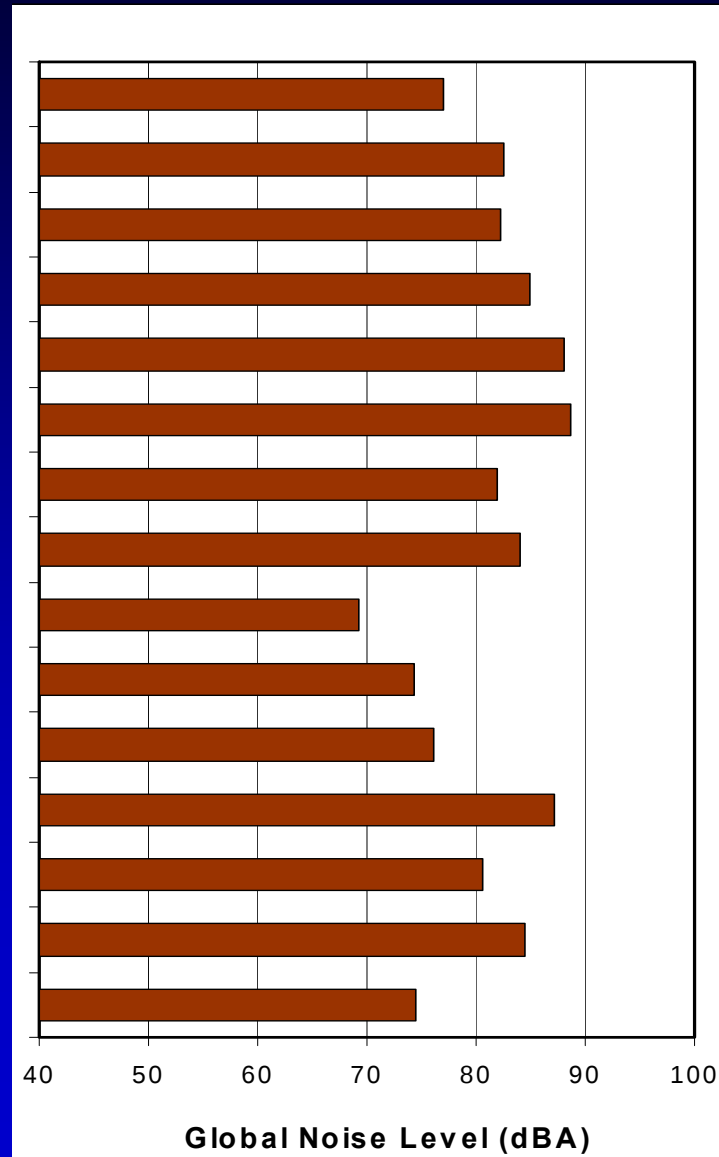
- loudspeakers

2 modes

- headphones
- loudspeakers

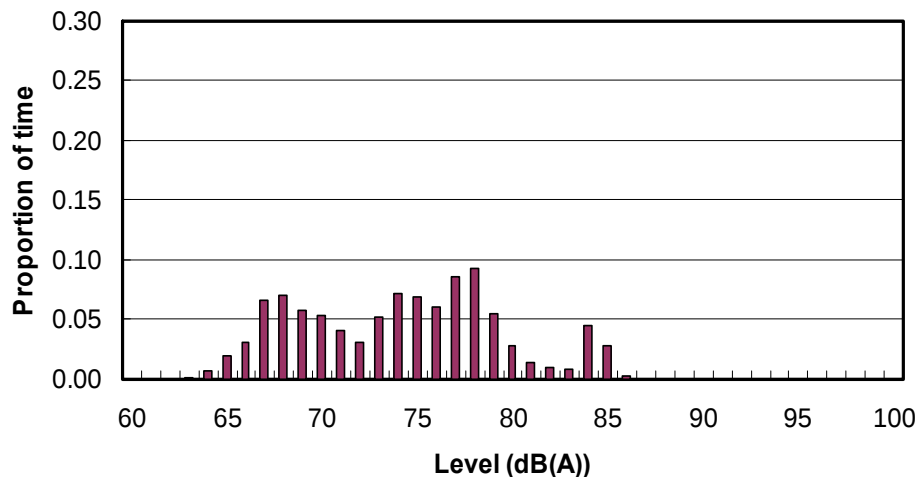
The 15 noise locations

- L1: Fishing boats (Fixed gear)
- L2: Fishing boats (Mobile gear)
- L3: Air patrol
- L4: Workboats & barges
- L5: RHIB/FRC
- L6: Main cabin & Rescue room
- L7: Deck side rescue
- L8: Deck front & mid fishing
- L9: Land patrol & Surveillance
- L10: Buoy deck & Winch room/ CTD
- L11: Engine control room
- L12: General machinery spaces
- L13: Bridge inside/Ships office/Radio rm
- L14: Bridge out./Monkey Is./Foc'le deck
- L15: Galley & accommodations



Noise distribution (2 Locations)

Noise distribution: Fishing boats

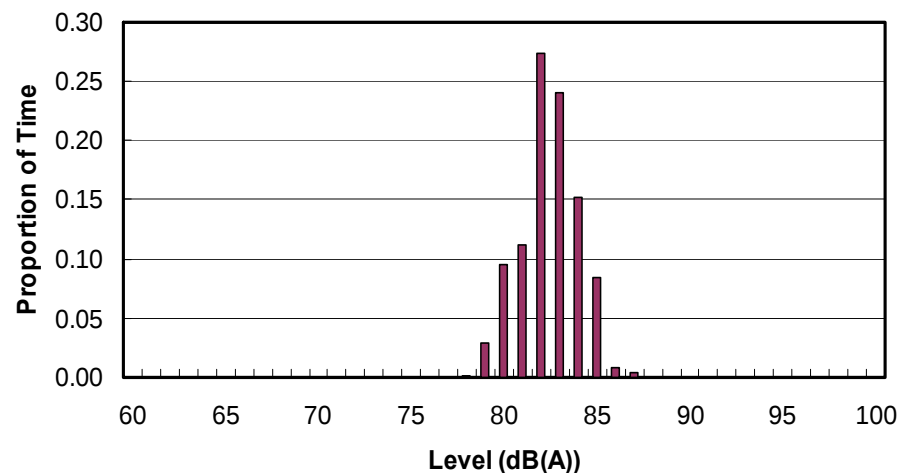


Location 1:
Fishing boats (fixed gear)

$$L_{eq} = 77 \text{ dB(A)}$$

$$L_{10} - L_{90} = 13.7 \text{ dB}$$

Noise distribution: Air patrol



Location 3:
Air patrol

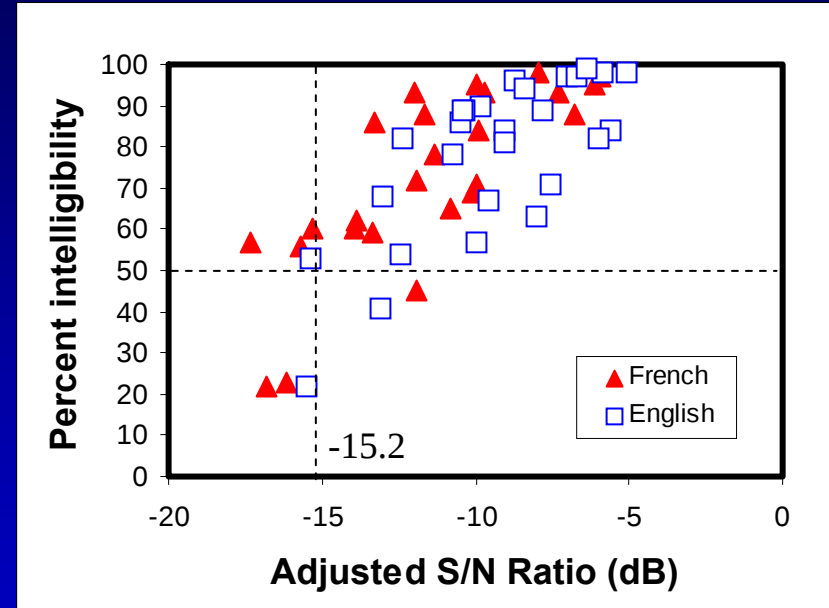
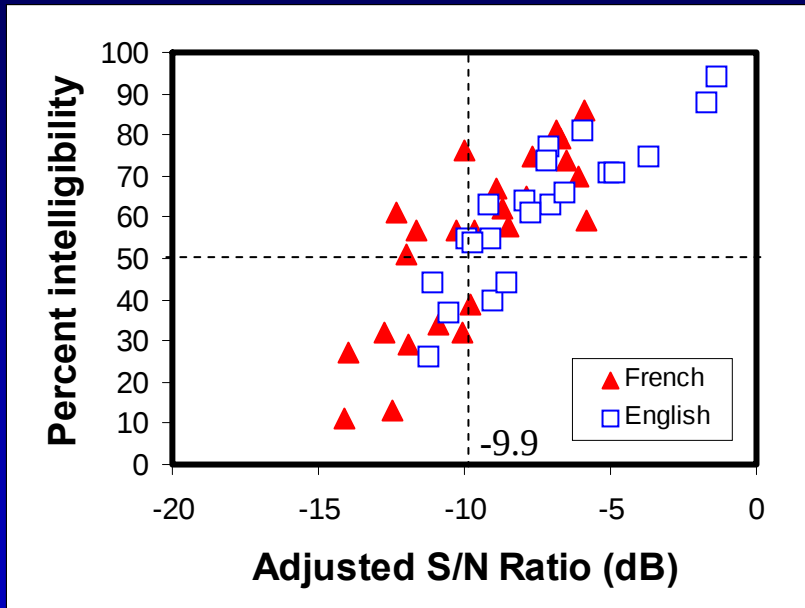
$$L_{eq} = 82 \text{ dB(A)}$$

$$L_{10} - L_{90} = 4.2 \text{ dB}$$

Procedure:

Speech intelligibility tests in the laboratory

Percent intelligibility as a function of S/N ratio



Location 1:

Fishing boats (fixed gear)

Offset = -9.9 dB

Location 3:

Air patrol

Offset = -15.2 dB

Offset = S/N ratio for 50% intelligibility

Procedure:

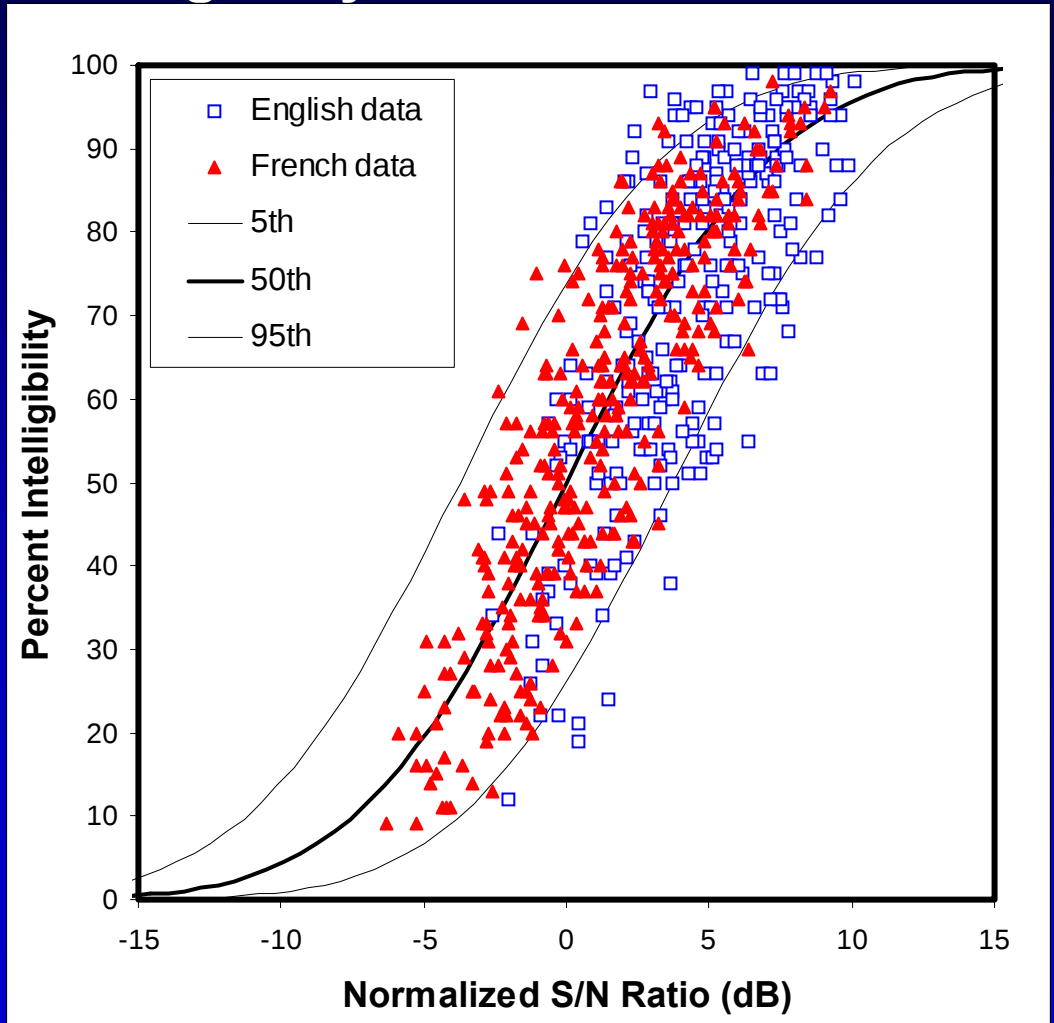
Functional hearing abilities (average NH individual)

% Intelligibility as a function of S/N ratio

S/N ratio for each data point normalized using:

1. Location offset (dB)
2. Deviation of subject's HINT screening score from average value for normal hearing (-6.35 dB)

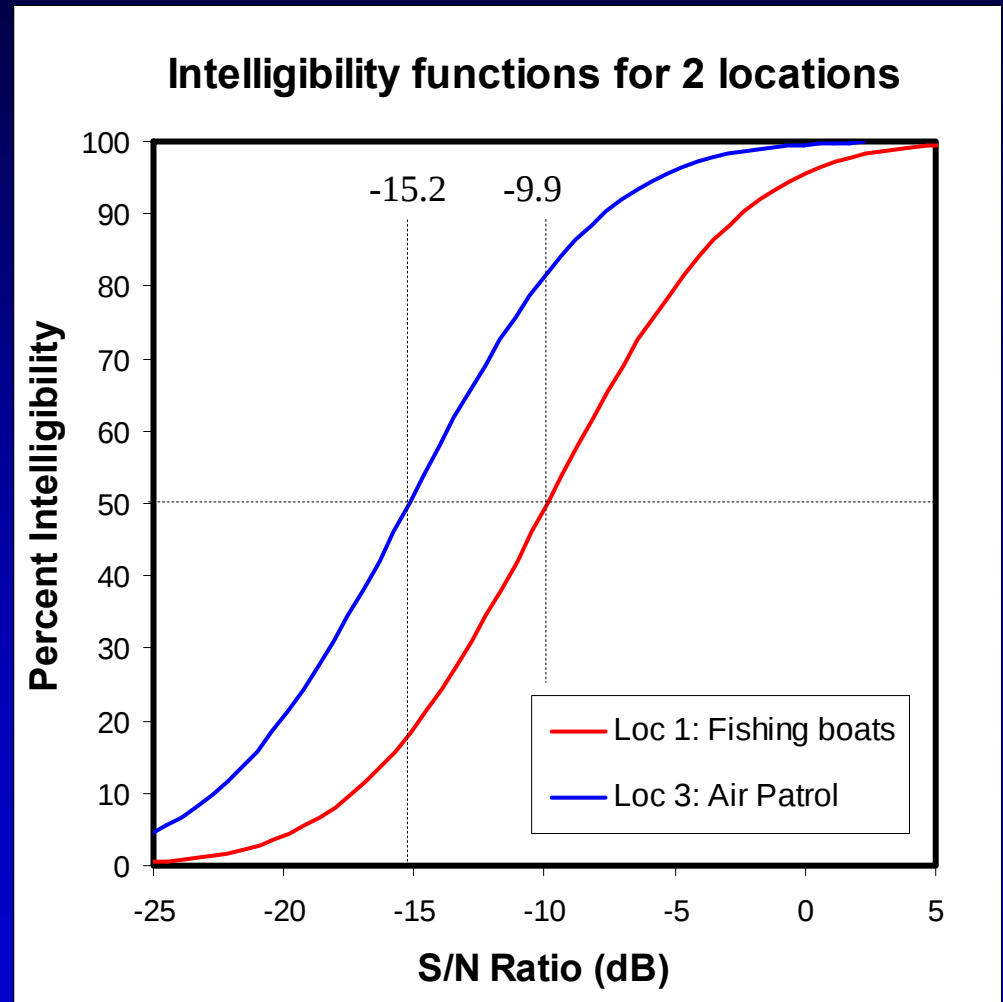
Pool all data and obtain normalized PI function



Procedure:

Obtain PI function for each location

- Restore location offset from the normalized PI function
- Resulting functions apply to an average normal-hearing individual

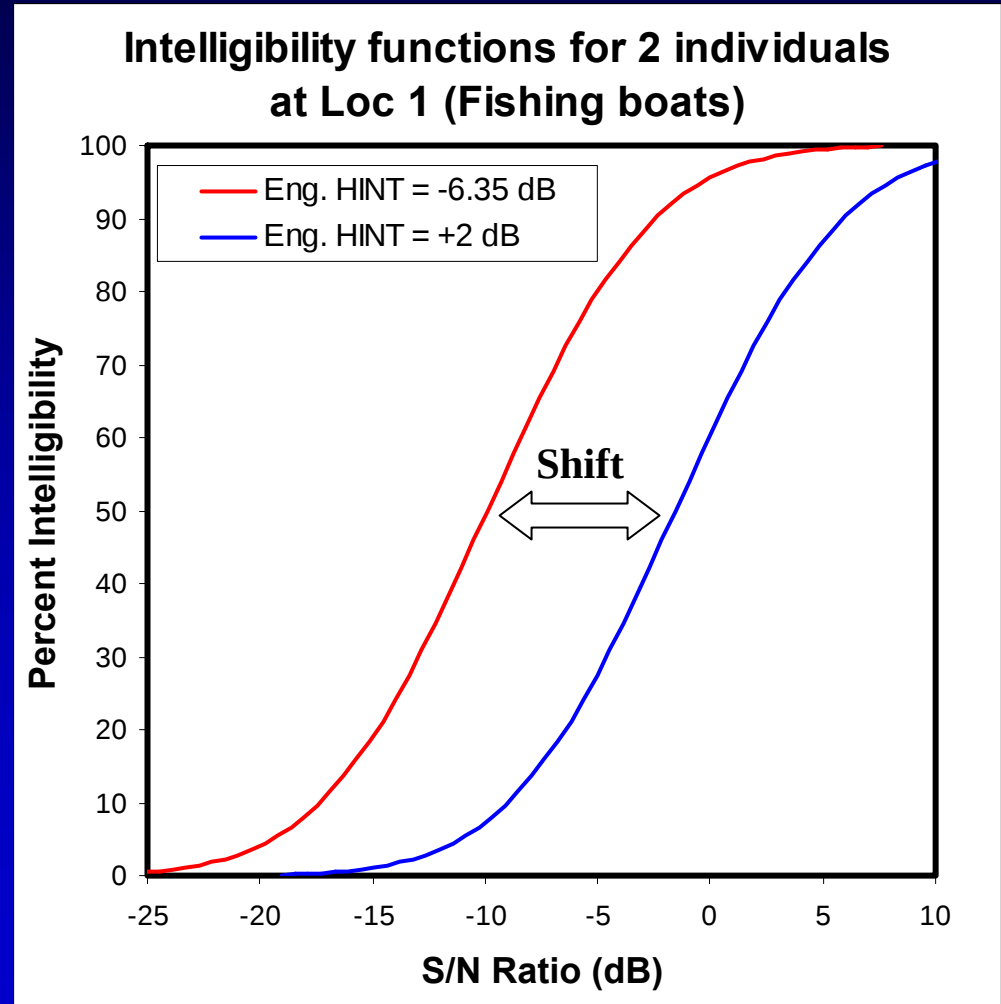


Procedure:

Obtain PI functions for different individuals

- ❑ Specialize the PI functions to different individuals
- ❑ Shift PI function by an amount (dB):

$$\text{Shift} = \text{Hint score} - \text{Norm}$$



Procedure:

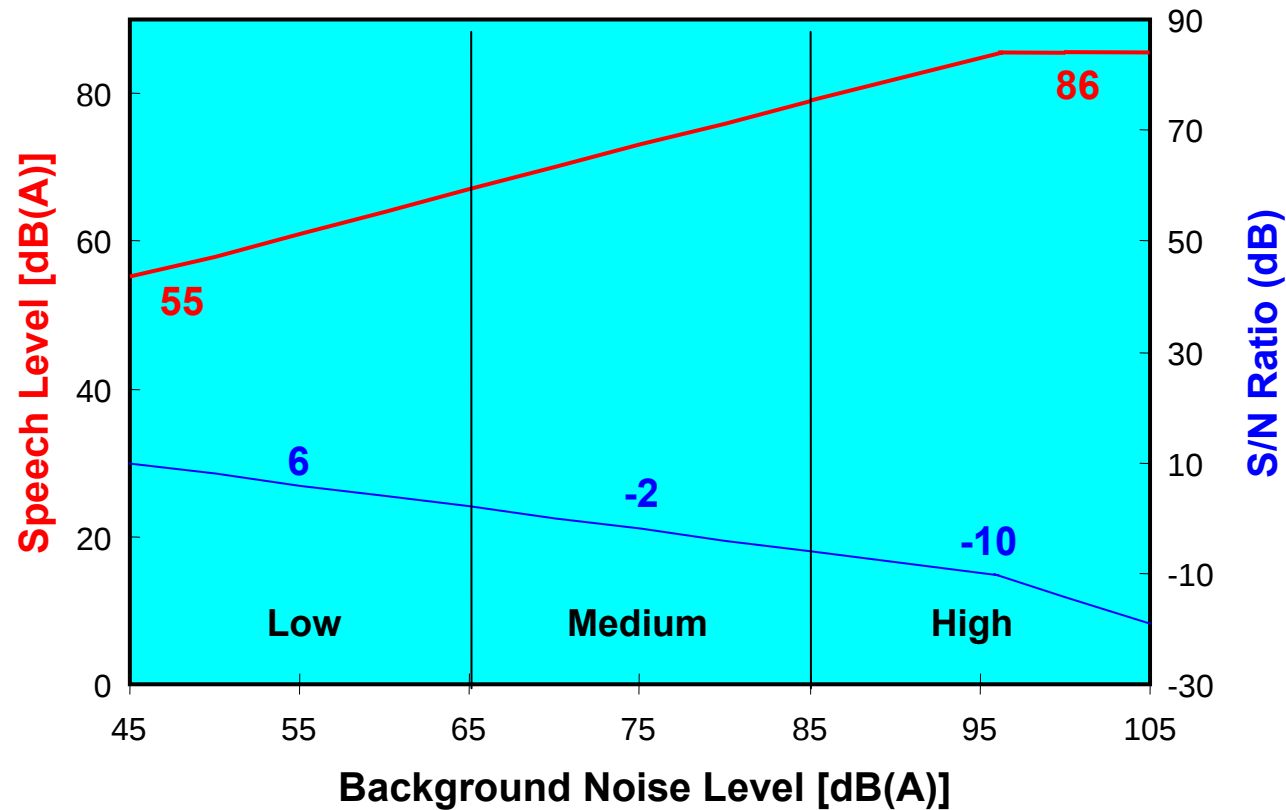
Predict occupational performance

- ❑ Estimate intelligibility for each individual in each location using PI function
- ❑ Find noise level distribution for each locations
- ❑ Predict the S/N ratios in each location based on the US Environmental Protection Agency 1977 study (Pearsons et al.)

Procedure:

Predict occupational performance

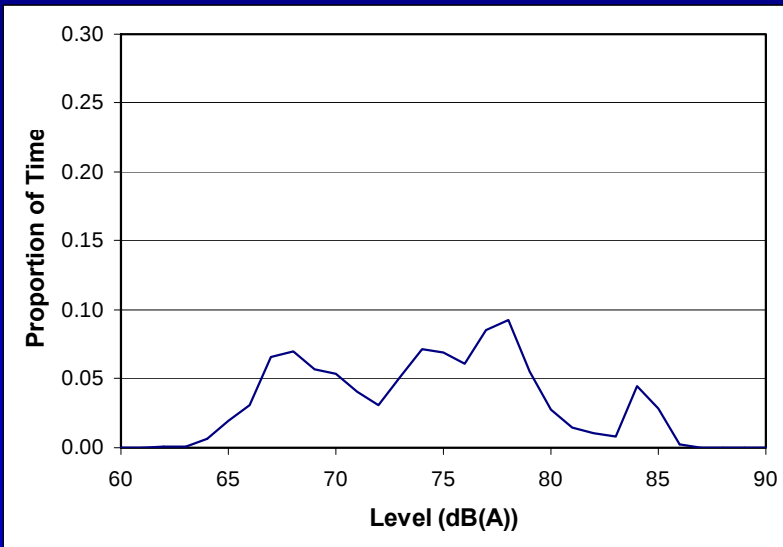
Normal Conversational Levels at 1 m in noise



Procedure:

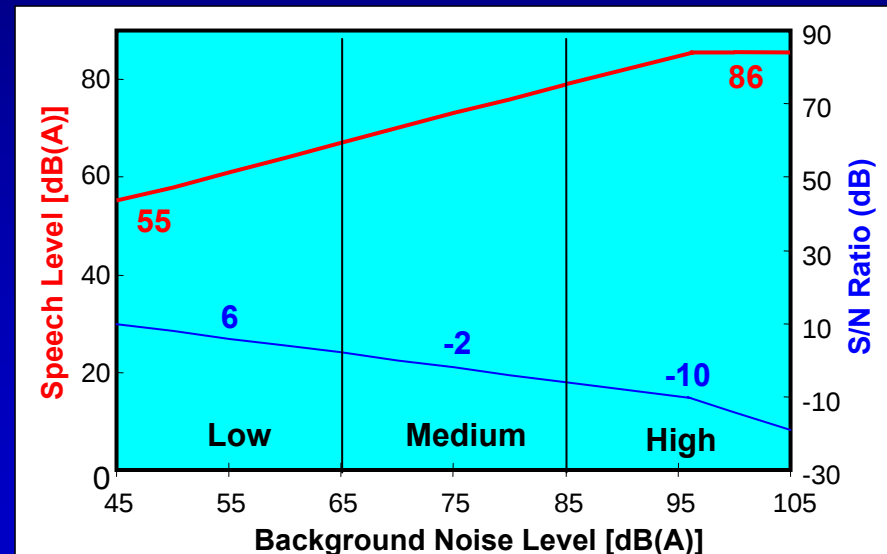
Predict occupational performance

Location 1 noise levels



X

S/N ratio as a function of noise level

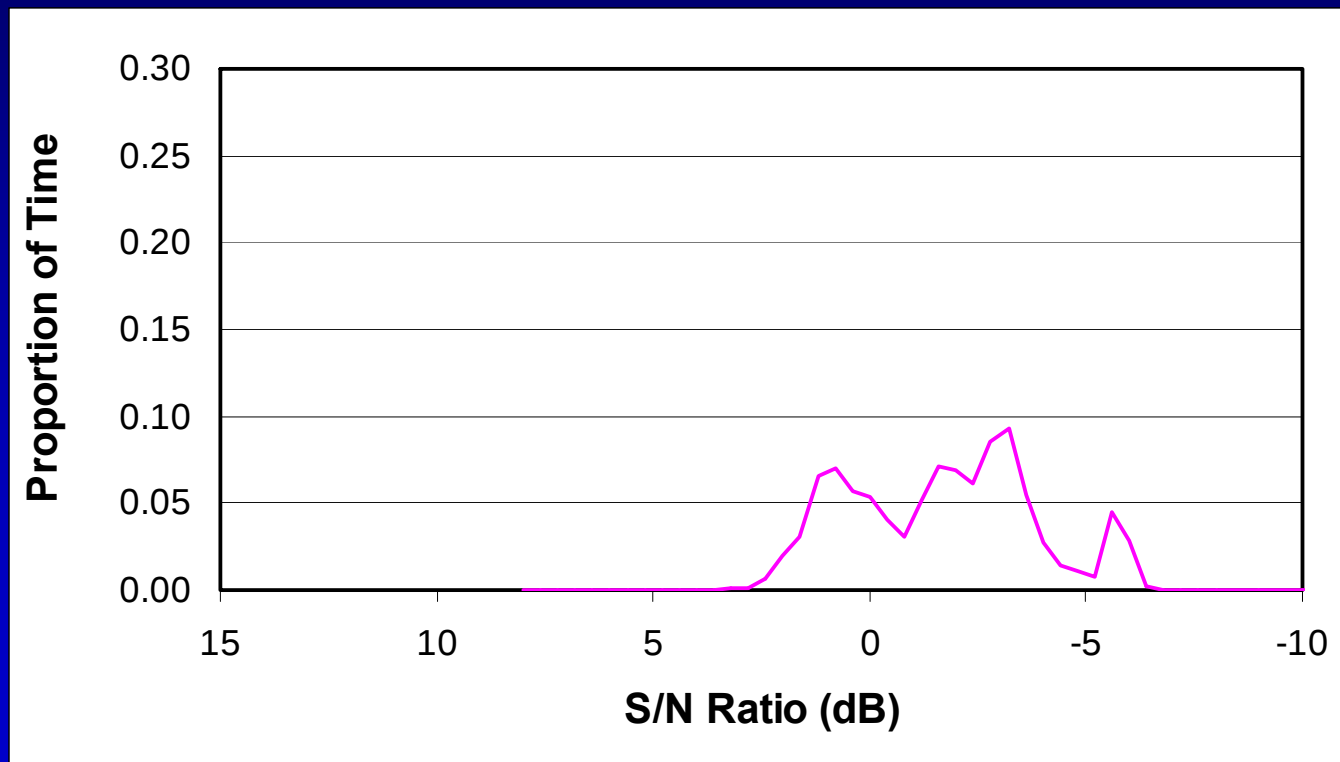


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Procedure:

Predict occupational performance

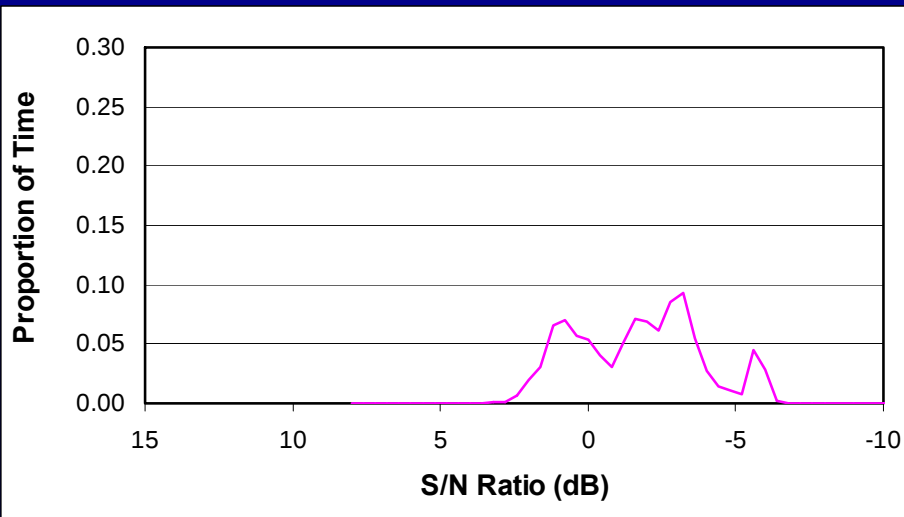
S/N Ratio Distribution for Location 1: Fishing boats (fixed gear)
Normal conversational level at 1 m



Procedure:

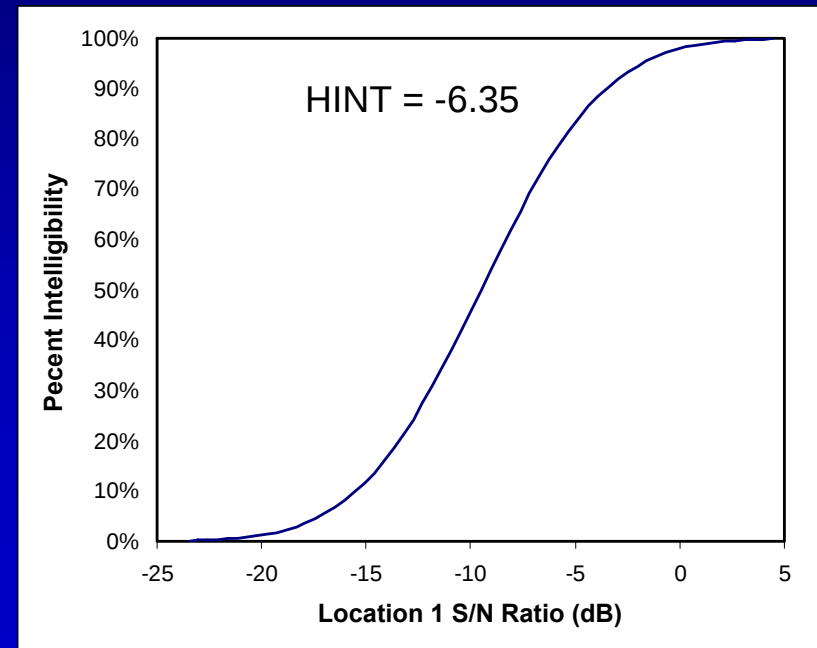
Predict occupational performance

Location 1 S/N ratios



X

Intelligibility as a function of S/N ratio

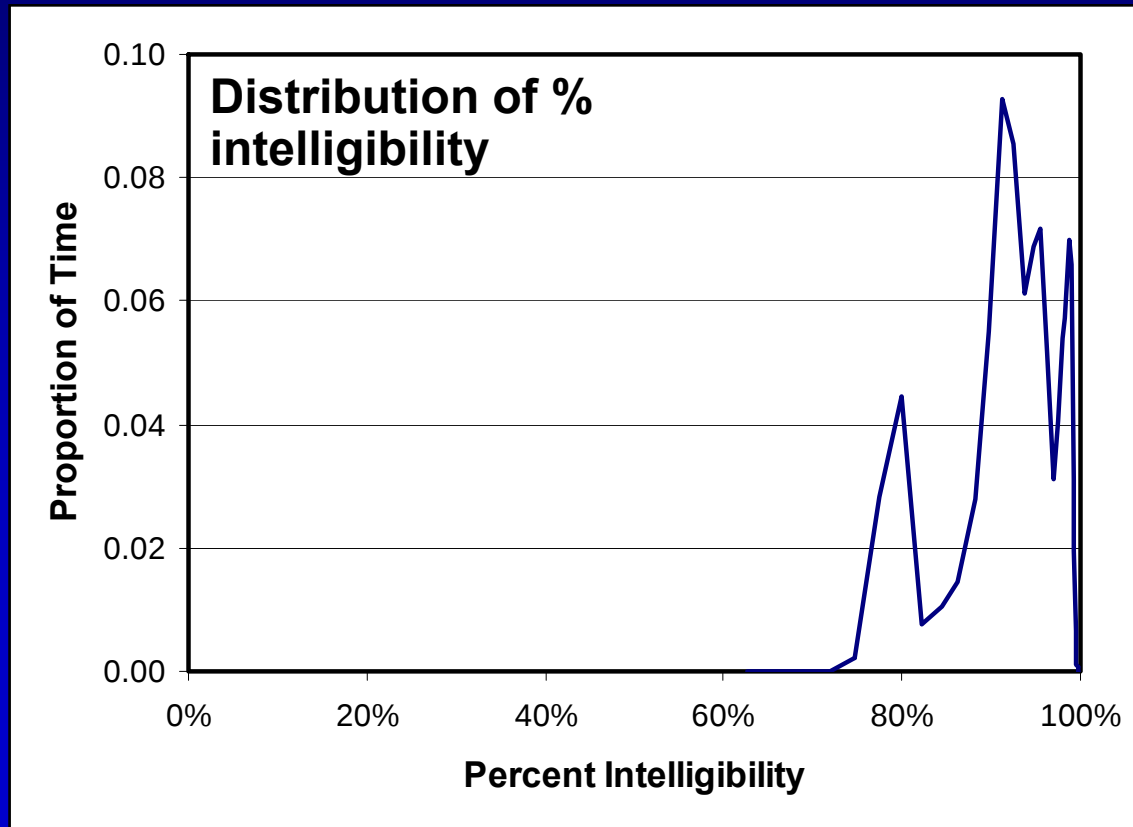


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Procedure:

Predict occupational performance

Predicted intelligibility for Location 1 for individual with HINT score of -6.35 dB



Compound
Intelligibility
Score
= 92%

Functional Screening Criteria

Results: Intelligibility

HINT screening tables for CCG and C&P tasks

- ❑ Use communication parameters (distance, vocal effort, repetition, %) from SMEs
- ❑ Identify noise intervals for which 95% of normal hearing individuals can perform at the specified parameters
- ❑ For some tasks and locations, very few (less than 50%) noise intervals were selected
- ❑ Compute minimum HINT screening score from these noise intervals

Screening Table

(excerpt from CCG - Newfoundland)

CCG TASKS: Newfoundland English			S=Speech, W=Warning, L=Loc.	RHIB/FRC	Main cabin/Rescue room	Deck side rescue/Rescue Zone	Deck front and mid	Buoy deck/Winch room	Engine control room	General machine spaces	Bridge/Ships office/Radio room	Monkey island	Galley/Accommodations	Communication distance	Repetition	Voice level (N=Normal, S=Shout)	Minimum intelligibility	Best screening score required
DEPT.	TASK	TASK NAME	AUD	5	6	7	8	10	11	12	13	14	15	Dst	Rep	Voi	%	Min
Gen	1.1.1	Communications on the Vessel	S-W-L	-2	-1	5	5	5	5	1	5	5	5	1	Y	S	90%	-2
Gen	1.1.2	Navigate the Vessel	S-W-L								2			1	Y	N	90%	2
Gen	1.1.3	Stand Watch	S-W-L								2			1	Y	N	90%	2
Gen	1.2.4 1.2.5	Launch Lifeboat/Life Raft Abandon Ship	S-W-L				X	-4						1	N	N	95%	-4
Gen	1.1.5	Access and Egress to/from Helicopter	S-W				5							1	Y	S	60%	5
Gen	1.2.3	Don Lifesaving Equipment	S-W-L	-3	-3	-2	-2	2	-2		2			1	Y	N	90%	-3
Gen	1.2.2	Human Overboard	S-W-L	X		X	X	1			3	2		9	Y	S	90%	1
Gen	1.4.2	Organize and Allocate Duties for Fire Fighting Drill	S-W-L	-2	-1	3	3	5	3	-2	5	4	5	1	Y	N	60%	-2
Gen	1.4.3	Prepare to Fight Fire and Fight Fire	S-W-L		5	4	5	5	0	5	4	5	5	1	Y	S	95%	0
Gen	1.5.1	Plan SAR Operation for a Determined Target	S-W-L		-2						5			1	Y	N	70%	-2

Implementation of the Functional Screening Program

Implementation of the Functional Screening Program

□ March 2005

- DFO - C&P/CCG presented *Functional Hearing Assessment* at Medical Officers Annual Meeting
- Implementation Committee struck (4 members)
 - Nurses to be trained to perform the testing
 - Nurses will be required to travel to do the testing
 - 30 HINT packages to be distributed across country
 - @ \$4K each, who will pay for the units?

Implementation of the Functional Screening Program (cont'd)

❑ December 2006

- DFO has the money
- Meeting with key players in Toronto

❑ March 2007

- Update at Medical Officers meeting in Ottawa
- Training in Halifax (English)
- Training in Vancouver (English and French)
- Equipment purchased and shipped by end of FY

Implementation of the Functional Screening Program (cont'd)

- ❑ Nurses happy with the training and generally enthusiastic about HINT
 - Concerns included time for testing, protocols, transition from old standards, travel....
- ❑ Pilot project began in BC Region
 - October 1, 2007
 - HINT standard implemented
 - Pure Tone Audiogram continued for hearing conservation
 - Pass/Fail data collected
 - Nurses began travelling with equipment

Implementation of the Functional Screening Program (cont'd)

□ Issues:

- Nurses had to reacquaint themselves with HINT
 - Bio-logic provided training CDs
- HINT/SAINT takes 20-30 minutes on top of ½ hour nursing assessment portion of medical
- Candidates became tired, frustrated confused
 - Increased number of failures off the top
 - =>Changes made
 - =>Testing became more successful

Implementation of the Functional Screening Program (cont'd)



Implementation of the Functional Screening Program (cont'd)

□ Issues (cont'd):

- What to do with candidates who fail
 - Refer to ENT
 - =>Expert opinion
 - =>Surgical option
 - =>Amplification
- How to test candidates who wear hearing aids
 - Test without hearing aids first
 - If unsuccessful:
 - => Soundfield testing at University of Ottawa

Implementation of the Functional Screening Program (cont'd)

❑ Issues (cont'd):

- How to get HINT tests done remotely when medicals are due



Implementation of the Functional Screening Program (cont'd)

□ The Future

- Full implementation on April 1, 2008
- Big challenges getting employees tested
 - No centralized testing of C&P/CCG personnel in Ontario region
 - Limited availability of HINT/SAINT outside of Health Canada
- But:
 - RCMP using HINT
 - Other federal agencies looking at HINT
 - Canadian Forces
 - Other federal departments served by WHPSP
- I have seen the Future – The Future is HINT

Laboratory listening tests with normal hearing subjects - 59 individuals

Listening tests with people with different degrees of hearing loss - 29 individuals

Validation of the model based on normal hearing performance - 102 employees

- ***Found that 97% of incumbents passed the HINT***
- ***All incumbents passed detection and localization***

SUMMARY:

Proposed Hearing criteria less restrictive

Out of 161 – 5 fewer failures with HINT/SAINT

What Do We Expect with the New Standard

- ❑ Fewer failures
- ❑ Where there is a failure – an indication why – i.e. detection, localization, voice
- ❑ Increased ability to accommodate
- ❑ Audiogram will remain
- ❑ Safer workplace